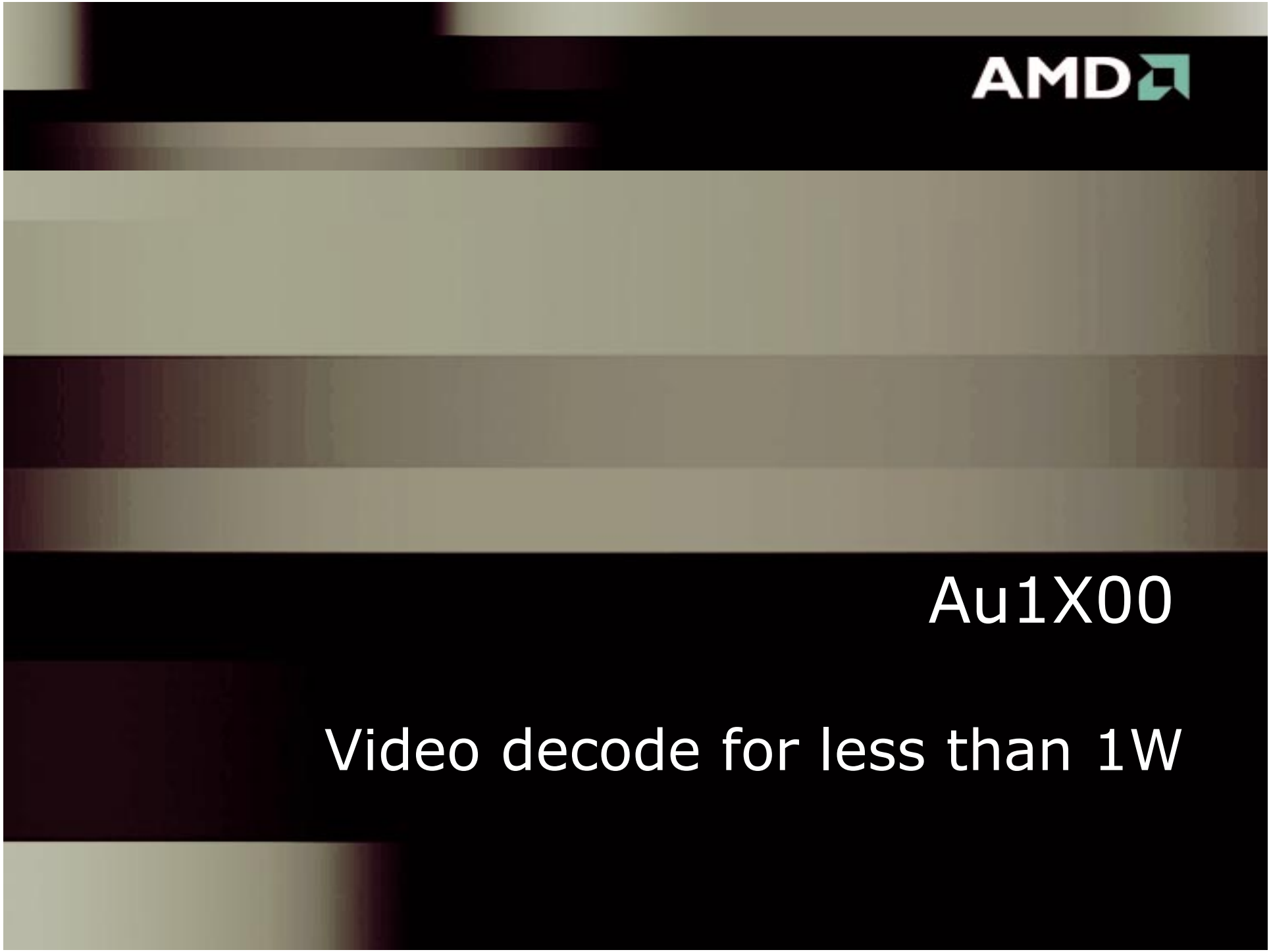

AMD
Au1X00
Video decode for less than 1W

Agenda

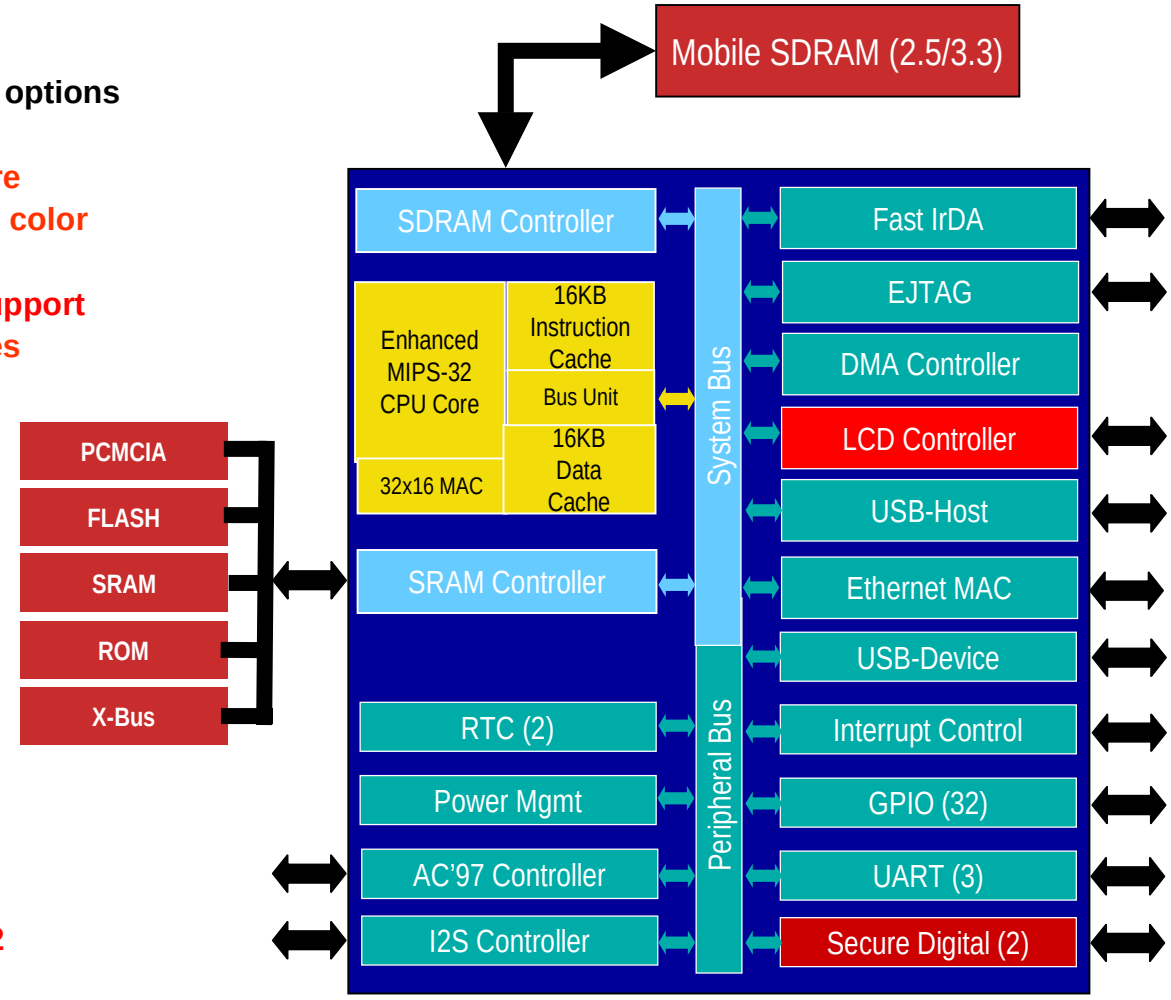
- Demonstration
- Three main topics:
  - **The Au1100™ Processor (and family)**
  - **Video performance in Au1X00 systems**
    - **System performance issues in embedded systems**
    - **Video performance on Au1X00 systems**
  - **Power dissipation while displaying video**
- Summary and conclusions

Video demonstration

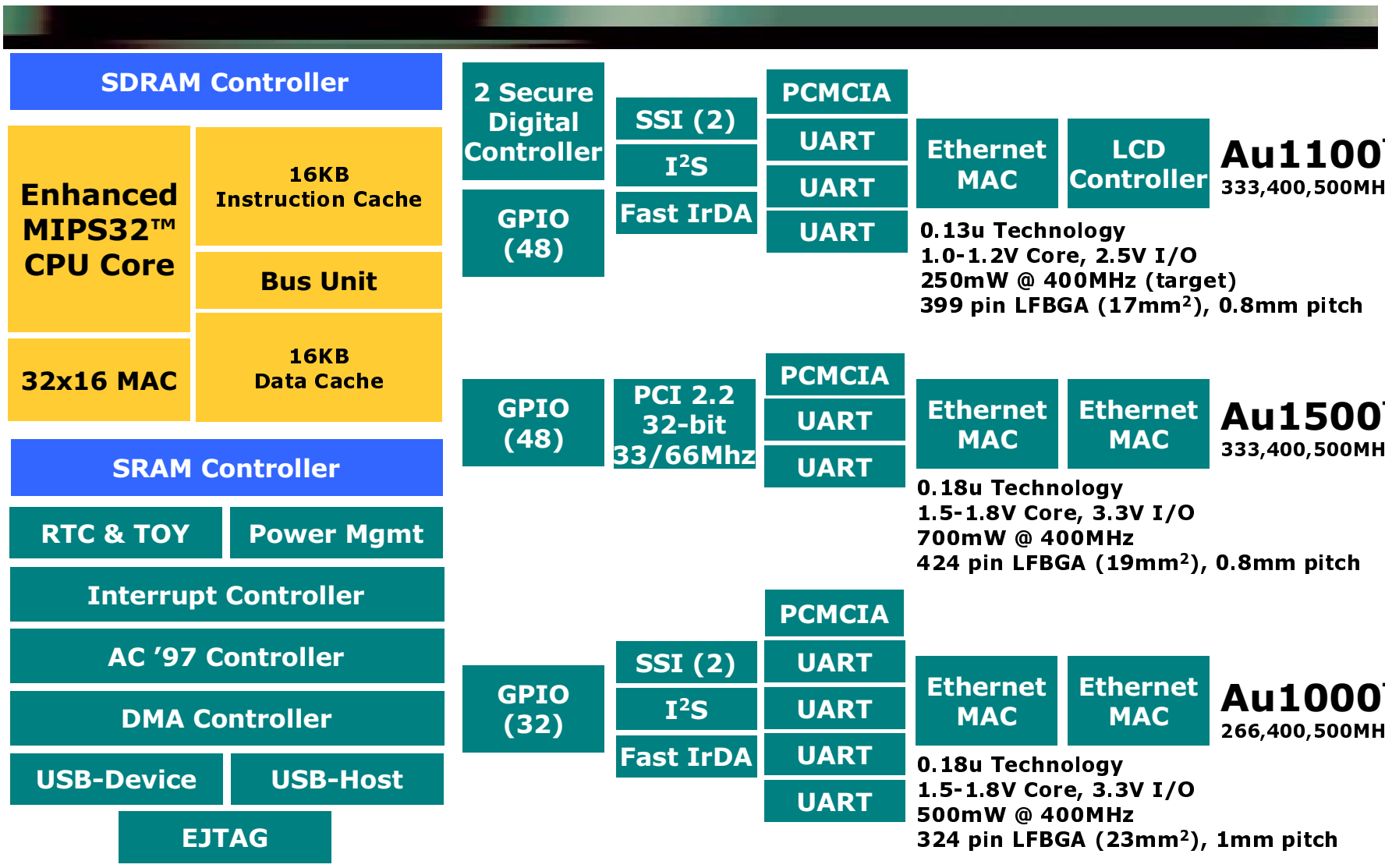
- What you just saw:
  - MI-2 movie trailer
  - Encoded at:
    - MPEG1 encode
    - 400 x 200 window size
    - 1100 kbps bit rate
    - 24 Frames per Second
  - Playback setup
    - MediaPlayer™ video player
    - WindowsCE™ OS
  - Played on
    - Pb1100 development platform
    - Au1100
      - 0.13um
      - 396MHz
      - <<500mW power

Au1100™ Processor
The first 0.13um AMD SOC

- Alchemy Au1 Core
  - 333, 400, and 500 MHz core options
- LCD Controller
  - Unified Memory Architecture
  - All panel types, up to 16-bit color
  - Hardware rotate (QVGA)
- 2.5 Volt/3.3Volt Mobile SDRAM Support
- 2 x Secure Digital / SDIO Interfaces
- Ethernet MAC
- 3 UARTs
- USB Host and Device
- Fast IrDA
- GPIO (TBD)
- AC'97
- I2S
- TSMC 0.13µ Process
- Low Power Consumption
  - 1.0 - 1.2V Core
  - 3.3 V I/O
  - 250mW @ 400MHz
- Package
  - 399 Pin PBGA, 17 x 17 mm2



Au1X00 SOC comparison



System-level Video Performance Issues

- Computation requirements of video decode (MPEG4/1)
- Memory system bandwidth utilization
- Performance/overhead of networking solution
- Integration/synchronization of audio and video outputs
- Can video decode be done in software on a <1W power budget?

Computational Components of Video Decode

- We studied 2 of the dominant components in MPEG4 video decode
  - Inverse Discrete Cosine Transform: up to 40%
  - Color Space Conversion: up to 25%

- Performance measured by two benchmark tests
  - IDCT loop: 81000 block transforms
  - CSC loop: 81000 YCbCr->RGB 8x8 block conversions
  - Results should be dominated by CPU, not memory system.

Projected Decode Performance

- Performance measurements/projections
  - Projected frames per second (FPS) are approximate

	CPU Cycles per CSC	CPU Cycles per IDCT	Projected FPS, 320x240, 504MHz
Au1500	**~5050**	**~2675**	**26**

- Benchmark measurements project full frame rate decode

System Performance Issues
Bus/Memory Bandwidth Utilization

- Bandwidth to/from frame buffer is valuable resource
  - Unified/Split memory architectures have very different performance characteristics

- There may be many consumers of bandwidth
  - Ethernet, video decode, frame buffer updates, audio, GUI overhead, USB mouse/keyboard input
  - Bus arbitration fairness may be an issue for satisfying real-time requirements of video display
    - The AuSB protocol supports shifting bandwidth allocation towards high-priority consumers.

Au1X00 Video Solution Bandwidths

- The effective bandwidth to the frame buffer varies widely depending on the video solution.
- Au1000™ Processor:
  - Glueless interface to inexpensive, low-power Epson controllers
    - 16-bit, 25-50MHz interface
- Au1500™ Processor:
  - Any PCI-based graphics solution
  - Example: ATI Xpert 98
    - 33MHz, 32-bit PCI interface
- Au1100™ Processor:
  - Integrated LCD controller
  - Full speed read/write access to SDRAM based frame buffer

Video Display System Bus Bandwidth Requirements

- For video decode, bandwidth usage will be dependent on the frame buffer update rate.
  - For example: at 30FPS, 16-bit color the bus bandwidth required is:

	FB write (MB/s)
QCIF (176x144)	**1.5**
SIF (320x240)	**4.6**
CIF (352x288)	**6.1**

- The complete decode operation will use 1.5-3X this much memory bandwidth depending on the details of the encoding scheme used.
- Available Au1X000 FB bandwidth:
  - Au1000™: good for lower end of the performance range
  - Au1500™ and Au1100™: cover full spectrum of decode performance

Memory System Impact

- Memory system dependence
  - The CPU-dominated benchmarks show a second-order dependence on the memory system.

	CPU Cycles per CSC	CPU Cycles per IDCT
Au1500, 396MHz, PCI graphics	**~5050**	**~2675**
Au1100, 396MHz, QVGA panel	**~5500**	**~2850**
Au1100, 396MHz, VGA panel	**~5975**	**~3150**

Video Display System Bus Bandwidth

- With a UMA display controller like the Au1100, a dominant bandwidth consumer is screen refresh.
  - Screen refresh accesses frame buffer at full SDRAM rate

	Refresh BW (MB/s)	% of AuSB BW w/ 100MHz SDRAM @ typical access rate
QVGA (320x240)	**11.7**	**5.6**
VGA (640x480)	**46.9**	**22.3**
SVGA (800x600)	**73.2**	**34.8**
XGA (1024x768)	**120.0**	**57.0**

Power Management

- The Au1X00 systems are very capable of supporting quality video decode solutions – what about power?

- The keys to power dissipation
  - Managing power in both Active and Idle processor states
  - Leveraging technological developments
  - High frequency operation allows more time spent in Idle

Au1X00: Managing Power

- Au1X00 family is designed for low-power operation
  - Custom circuit design allows high-speed operation at low voltage
  - Very aggressive use of clock gating

- At the system level the Au1X00 solutions allow:
  - Multiple frequency scaling options
    - Support for static, semi-static and dynamic frequency changes.
  - Dynamic Voltage scaling
    - Power supply can track the operating frequency:
      - 500MHz/1.8V, 400MHz/1.4V, <333MHz/1.2V

- Typical Au1X00 Active:Idle power ratio: 3-4X

Technology Enhancements

- Power savings from moving to 0.13um and Mobile SDRAM
  - Core nominal operating voltage
    - 1.4V -> 1.0V reduces core power by ~2X
  - Mobile SDRAM
    - 3.3V -> 2.5V reduces I/O power by ~1.75X
    - The new SDRAMs also have additional power saving modes

Au1X00: Idle Time

- Active:Idle ratios while playing video clips

System	Video clip encoding	% idle	Chip power
Au1500, ATI PCI card	**Low complexity**	**85-90**	**<300mW**
Au1500, EPSON controller	**Low complexity**	**45-50**	**500mW**
Au1500, ATI PCI card	**High complexity movie trailer**	**30-35**	**600mW**

- High performance design reduces system power

Summary

- Good video performance does not require high power
- Demonstrated full frame rate video decode at <0.5W
- The Au1X00 family allows tuning system performance and power to meet a range of applications.

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